



RF Exposure Procedures Update

**FCC / OET
Laboratory Division**

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TCB Workshop



Overview

- product and technology related
 - LTE MPR
 - wireless routers (hotspots), UMPC mini-tablet devices
- test procedures related
 - proximity sensing, power reduction
 - simultaneous transmission configurations
 - transmitter and antenna paths, device use and exposure conditions
 - SAR exclusion
 - MIMO configurations
- policy related
 - product platforms, accessory antennas
 - other clarifications
 - duty factor, device test power, SAR system verification
 - SAR numbers, multiple transmitters & grant notes
 - typical causes for KDB inquiry delays
 - PBA status: HSPA+, WiMax, PTT etc.
 - plans for KDB 616217
- general discussion



Product and Technology Related



LTE SAR Test Issues

● typical issues

- simultaneous transmission configurations should be identified according to
 - the head, body-worn accessories, hotspot mode & other use exposure conditions
 - in the supported voice & data mode combinations
 - for the wireless modes & technologies, device design and use requirements
 - » handsets, mini-tablets, laptops/notebooks, USB dongles, transmitter cards etc.
 - the transmitter & antenna paths used by the wireless mode combinations
 - for voice & data transmissions
 - SAR exclusion and measurement requirements
 - by applying the procedures in KDB 648474 to perform SAR exclusion analyses, or
 - perform volume scan SAR measurements, if required
- MPR
 - measured power results are often inconsistent with product specifications
 - due to output variations or unclear specifications
 - need to list MPR specs along side power & SAR data for results to be meaningful
 - because SAR results are dependent on power; therefore, power is essential for determining compliance



LTE SAR Test Issues

(continued)

- unclear power reduction specifications & implementation criteria
 - power reduction is often applied to selected modes, conditions or frequency bands only
 - different power thresholds are often applied to different device use conditions and configurations
 - need to list power reduction specs along side power & SAR data for results to be meaningful
 - SAR results must be associated with specific power levels to determine compliance
- most power reduction requirements, including MPR, often involve multiple reduction levels across different wireless modes, signal modulations and use conditions
 - an attestation to clearly identify the applicable combinations and configurations should be considered to avoid issues and confusion during review and approval for equipment certification
- when SAR results are close to the limit, tune-up tolerances must be considered to determine compliance
- the LTE procedures in KDB 941225 are sometimes not properly applied



LTE - MPR

3GPP Recommendations							
Modulation	Channel Bandwidth (MHz) & RB Configurations						MPR (dB)
	1.4	3.0	5	10	15	20	
QPSK	> 5	> 4	> 8	> 12	> 16	> 18	≤ 1
16 QAM	≤ 5	≤ 4	≤ 8	≤ 12	≤ 16	≤ 18	≤ 1
16 QAM	> 5	> 4	> 8	> 12	> 16	> 18	≤ 2

- MPR implementation targets (product specs) must be clearly identified to support the SAR test setup & results
 - especially only some of the 3GPP recommendations are implemented
 - when measured outputs have larger than expected variations, MPR requirements may not be easily determined without clear specifications
- SAR should be measured within the specified tolerance range of production units when MPR is a permanent built-in feature
 - SAR results may be unacceptable when a device is tested in overdriven or under-power configurations



Wireless Routers

- a KDB publication on SAR procedures for wireless routers, also called hotspot mode, has been published
 - as an attachment to KDB 941225 (3G procedures)
- the procedures provide test guidance for
 - standalone battery operated personal wireless routers ≥ 9 cm x 5 cm (~3.5" x 2")
 - including those that require a plug-in peripheral transmitter to operate
 - wireless handsets (≥ 9 cm x 5 cm) with wireless routing capabilities
- SAR must be tested for all surfaces and edges (sides) with a transmitting antenna within 2.5 cm from that surface or edge, at a test separation distance of 10 mm, in the wireless modes that support wireless routing
- standalone wireless routers and handsets with form factors < 9 cm x 5 cm should be tested with a separation distance ≤ 5 mm to qualify for TCB approval
- when the required procedures are not followed
 - due to unusual device configurations, form factors or any other reasons
 - a KDB inquiry is required for further consideration
 - when test distance is > 10 mm, TCB exclusion list requires FCC filing
 - PBA may be required for other deviations



Wireless Routers

- the 10 mm test separation distance for hotspot mode
 - covers the multiple use exposure conditions for
 - battery operated standalone wireless routers and typical cellphones
 - in near-body and hand-held use configurations
 - the procedures are not intended; therefore, not applicable for transmitters used in other host or product platforms; for example,
 - laptop computers, notebooks, netbooks, regular tablets, UMPC mini-tablets etc
 - because of different operating configurations or exposure conditions
- hotspot mode requires
 - sustained simultaneous transmissions from multiple transmitters
 - transmissions are “unattended” and “transparent”
 - where users normally do not know when or how transmissions may occur
- hotspot mode for other device form factors or host platforms
 - may require individual considerations until product trends are established
 - a KDB inquiry is recommended to determine test requirements; for example,
 - certain intermediate to full size tablets using different antenna configurations in power reduction mode and different display orientations
 - smart phones with multiple displays involving additional use & exposure conditions



Standalone Wireless Routers

- standalone wireless routers typically support hotspot mode by routing wireless traffic between
 - a built-in, short range WLAN transmitter and one or more 3G/4G transmitters for internet access
 - using GPRS/EDGE, EVDO, HSPA, WiMax, LTE etc
 - 3G/4G transmitter support can be built-in or through an external plug-in device, such as an approved USB dongle
 - since various plug-in devices may be used and SAR evaluation is not practical, the SAR for such transmitters must be assumed to be 1.6 W/kg to qualify for simultaneous transmission SAR test exclusion
 - the peak SAR location for USB dongles must be conservatively assumed to be at 1 cm or less from the USB connector
 - the peak SAR location for plug-in cards must be assumed to be at the edge of the wireless router, centered along the width of the plug-in card slot
 - all transmitting antennas that are built-in, on or inside the wireless router, within 2.5 cm from any surface or side (edge) must be tested for SAR at a test separation of 10 mm



Wireless Routers in Handsets

- cellphones with hotspot mode must address SAR compliance
 - in head, body-worn accessory and other near-body use conditions
 - for the frequency bands, wireless modes/technologies, transmitter/antenna paths, simultaneous transmission configurations and conditions etc.
 - combinations of voice and/or data simultaneous transmissions require either SAR exclusion analyses or volume scan SAR measurements
- the 10 mm hotspot mode test distance covers other near-body use conditions, which is independent of the body-worn accessory test requirements
 - Supplement C specifies 0-25 mm for body-worn accessory testing
 - 15 mm may be suitable for the larger form factor 2G phones from 2001
 - recent generation handsets must be tested according to the body-worn accessories available to the users



Wireless Routers in Handsets

(continued)

- the more conservative test configuration required for hotspot mode & body-worn accessory use may be tested to support both conditions
 - for example, the back of the phone tested in UMTS mode where 12.2 kbps RMC covers both voice & data may be tested at the smaller distance to cover both body-worn accessory and hotspot mode use
- when hotspot mode is supported during voice calls
 - for example, UMTS, GSM/GPRS with DTM, voice & data on separate transmitters
 - simultaneous transmission must be addressed separately for head and body-worn accessory use conditions according to the supported voice & data mode combinations
 - either by SAR exclusion analyses or volume scan measurements
- simultaneous voice & data configurations are expected to evolve
 - handsets & smart phones with new transmission combinations or configurations may require KDB inquiry to address test requirements
- be aware of permissive change & approval policies for using software & firmware field update/upgrade to include hotspot mode in already deployed products



UMPC Mini-Tablet Devices

- similar approach used for hotspot is applied to UMPC mini-tablet devices with an overall diagonal dimension < 20 cm
 - to address varying near-body and hand-held use exposure conditions
 - devices are primarily intended for interactive hand use near the user's body
 - a test separation distance of 5 mm is required
 - 1-g SAR at 5 mm also covers hand exposure
 - 10-g extremity SAR at zero test separation is not necessary
- the procedures are described in a KDB publication
 - attachment to KDB 941225 (3G)
- when the required procedures can not be followed
 - a KDB inquiry is required for further consideration
 - PBA is required for TCB approval



UMPC Mini-Tablets

(continued)

- a test distance up to 10 mm may be considered for certain device configurations
 - according to device form factor, antenna locations, operating configurations and exposure conditions etc
 - must submit KDB inquiries to determine test distance
 - 10-g SAR at zero separation is also required for all the 1-g SAR test configurations to address hand exposure
- simultaneous transmission SAR exclusion
 - the analyses must be applied independently according to
 - the frequency bands, wireless modes & technologies, voice & data configurations, proximity sensor and power reduction considerations etc
 - if hotspot mode is applicable, separate SAR is generally not necessary
- the procedures may be adapted to test devices with similar form factors and use conditions; for example,
 - certain wireless gaming controllers, smart phones with dual displays
 - mini-tablet procedures generally do not apply to full size tablets
 - must submit KDB inquiry to confirm test requirements



Test Procedures Related



Proximity Sensing

- proximity & similar sensing mechanisms have been used
 - in device such as mini-tablets to trigger power reduction under certain operating configurations, exposure conditions, wireless modes or frequency bands
- when submitting a KDB inquiry to determine SAR test requirements
 - the detection range and sensitivity within the coverage regions of a sensor in all applicable directions must be clearly identified
 - data for demonstrating the reliability & consistency of the sensor triggering distance and power reduction levels are also needed to establish test requirements
 - similar considerations may apply to larger tablets using other mechanisms to detect display orientation and reduce output power
- SAR is typically tested in power reduction mode at the separation distance required for the device type; for example, 5 mm for UMPC mini-tablet devices and 10 mm for hotspot mode; SAR is also required at the closest distance (or display orientation for larger tablets) from a user when full power is restored



Proximity Sensing

(continued)

- the amount of power reduction must be clearly specified and confirmed by power measurements
 - especially when different levels of power reduction are applied to different operating modes and configurations
 - how power reduction affects the various simultaneous transmission conditions must also be clearly identified to support the test configurations & results
- in most situations, when the test separation distance is within the triggering tolerance range of the sensor, full power must be set manually with power reduction disabled to perform SAR measurements
- there must be sufficient descriptions & explanations in the SAR report to support the test setup and results
 - the target power reduction levels must be listed along side the power & SAR data for results to be meaningful
 - certain qualified confidential information may be included in the Technical Descriptions; for example, sensor design specifics
 - the confidential information must be referenced in test reports when it is required to support the test setup or results



Power Reduction

power reduction has been applied to devices in selected wireless modes, frequency bands, operating configurations etc

- a typical device may require multiple power reduction levels. which could be triggered by proximity sensors or other transmitter and use conditions
- the reduction levels must be clearly specified and verified in the applicable operating modes for both full and reduced power conditions according to
 - the supported voice and data modes
 - this also includes different outputs used for GMSK & 8-PSK for EGPRS/EDGE
 - head, body-worn accessory and hotspot mode use conditions, as appropriate
- the reduction levels must be listed along side the power & SAR data for results to be meaningful
- when power reduction applies, KDB 447498 procedures for tablets may not apply
 - a KDB inquiry with details are necessary to determine SAR test requirements
- the triggering mechanism and conditions must be clearly described and explained in the SAR report to support the test setup
 - for example, triggering could be controlled by specific sensors, device orientations, wireless modes, other device operating conditions or firmware control etc
 - any operating restrictions must also be clearly explained in the SAR report to support the test setup and results
- when simultaneous transmission applies
 - SAR exclusion may be determined using the standalone SAR tested at full power
 - volume scan measurements must use the maximum power allowed for the power reduction mode



Transmitter & Antenna Paths

- recent products with multiple transmitters and antennas have introduced certain complex simultaneous transmission configurations
 - various MIMO & transmit diversity configurations
 - separate voice & data transmission paths; for example,
 - 1xRTT & LTE/EV-DO
 - 1xRTT/EV-DO & LTE
 - 1xRTT/EV-DO & WiMax
 - UMTS & LTE
 - GSM/GPRS/DTM & LTE
- the simultaneous transmission configurations for voice, data, hotspot mode or other use conditions must be considered separately
 - for head, body-worn accessory and other multi-use conditions
- SAR test requirements may vary with transmitter & antenna paths
 - for the simultaneous transmission SAR exclusion analyses
 - when power reduction is implemented for certain configurations only
 - or due to other device operating restrictions



Simultaneous Transmission

- the supported simultaneous transmission configuration combinations must be clearly identified in the SAR report
 - to support the SAR exclusion analyses, volume scan configurations and test reduction considerations
 - for the voice & data modes and according to
 - transmitter & antenna paths
 - wireless modes & frequency band combinations
 - exposure conditions – head, body-worn accessories, multi-use etc
- when applying SAR to peak location ratio for SAR exclusion
 - the peak locations must be based on the x, y & z coordinates identified in the zoom scans by the SAR system
 - distance is computed as $\sqrt{(x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2}$
 - area scan plots are used to show the relative peak locations
 - may need to inquire with SAR system manufacturer on how to extract the x, y, z coordinates if application notes or instructions are not readily available



Phones with Bluetooth & Wi-Fi

- the procedures in KDB 648474
 - requires standalone SAR measurement for certain low output unlicensed transmitters in handsets, such as Bluetooth
 - to facilitate streamlining simultaneous transmission SAR exclusion considerations
- the standalone Bluetooth SAR required by KDB 648474 may be optional for head, body-worn accessory & hotspot mode
 - when 2.4 GHz Wi-Fi and Bluetooth are implemented in the same chipset, using the same antenna and RF components
 - Bluetooth source-based time-averaged power is $< 60/f_{(\text{GHz})}$ mW
 - the maximum peak & average output for Bluetooth are less than the output power in all Wi-Fi modes
 - the measured Wi-Fi SAR is < 0.4 W/kg for the applicable configurations that require the Bluetooth SAR measurement
 - simultaneous transmission SAR exclusion applies to all applicable configurations involving Wi-Fi or Bluetooth; i.e., no volume scan required



MIMO

the sum of antenna gains and aggregate power should not be used to perform MPE analyses

- MPE should be estimated for the group of antennas using individual antenna gains
- the parameters of interest for interference and RF exposure are different
- preliminary SAR procedures are available for 802.11 devices in KDB 248227
 - for simple 2x2 spatial multiplexing MIMO
 - specific guidance for other MIMO or diversity configurations are unavailable
- additional info is required to determine 3x3 or higher order MIMO and other antenna diversity test requirements
 - output power measurements of individual transmitter/antenna chains in each type of transmit diversity (SISO, cyclic delay, spatial multiplexing, time-space code etc)
 - how the different transmitter/antenna chain combinations can be used for SISO, 2x2 or other antenna diversity configurations
 - SAR test requirements for individual chains and combinations of chains can depend on device implementation; for example,
 - output variations of individual chains
 - SAR distributions of individual chains may vary due to antenna locations and other factors; therefore, may affect the SAR distribution of multiple chain contributions
 - SAR measurements with multiple chains transmitting simultaneously are needed
 - SAR test requirements should be confirmed through KDB inquiries
 - PBA may be necessary when procedures are unavailable or non-standard procedures are used



Policy Related



Device & Host Platforms

- KDB 447498 provides SAR test procedures for transmitters and modules used in different host platforms
 - according to SAR level and minimum test separation distance requirements
- when the measured SAR is high; for example, USB dongles or similar peripheral adapter transmitters
 - the transmitter may be limited to a single platform or dedicated host(s)
 - if lower SAR is expected for certain OEM variant configurations
 - due to larger separation distance requirements in the OEM configurations
 - certification under a separate FCC ID would generally alleviate many of the difficult issues and concerns
 - specific OEM requirements can be implemented independently of the consumer version that required restrictions due to high SAR
- for different host platforms with substantially different operating configurations and exposure conditions
 - when significantly different test requirements must be considered, a separate FCC ID is recommended to avoid policy & approval difficulties
 - when conservative SAR testing is applied to each platform, subsequent permissive change issues may also be minimized



External Antenna Considerations

- external antennas may be supplied as accessories for certain devices
 - for example, USB dongles, plug-in cards, standalone hotspots etc
 - accessory use conditions are often dictated by the exposure category applicable to the transmitter
 - external/accessory antenna configurations for devices certified to operate in portable exposure conditions generally need to comply with SAR requirements according to a certain minimum test separation distance
 - however, there could be exceptions due to specific design, use and installation requirements, which must be considered on a case-by-case basis through KDB inquiries
- the criteria to incorporate accessory antennas may vary with
 - MPE and SAR compliance considerations
 - consumer use vs. OEM integration requirements
 - product platforms, operating and exposure conditions
 - installation requirements and expected use conditions
 - device & antenna characteristics across applicable frequency bands
- the requirements of §2.1091(d)(4) must also be considered to determine compliance for external antennas used in mixed mobile-portable conditions



Low Duty Factor Devices

- when routine SAR evaluation is required
 - certain transmitters with low duty factors may demonstrate compliance by SAR analyses
 - with respect to source-based time-averaged power
 - inherent low-use and worst case operational characteristics
 - to be considered through KDB inquiries
- the factors for consideration may include
 - maximum source-based time-averaged power $< 60/f_{(\text{GHz})}$ mW
 - worst case operating characteristics and exposure conditions
 - maximum duration of transmission for voice and data activities
 - other inherent device implementation limitations
- a combination of SAR analysis and test reduction provisions may be considered for certain circumstances
 - according to the design, operating characteristics and exposure potentials of the product



Device Test Power

- a transmitter must be tested within its specifications, which are typically determined by
 - transmitter tune-up tolerances
 - other manufacturing and production specifications
- transmitters should not be tested at power levels outside of the product specifications
 - to avoid potential issues that may affect device operating characteristics and test results
 - devices tested outside of its specifications may require PBA or FCC filing, provided the results are acceptable
 - for meeting §§2.907(b) and 2.908 requirements
- tune-up tolerances must be considered to determine compliance when the measured SAR is high
 - for both standalone and simultaneous transmission
 - including SAR test exclusion considerations



SAR System Verification

earlier proposal to enable SAR system verification using either head or body tissue dielectric parameters when both are required to test a device

- this did not get adopted in the final release of KDB 450824
- due to comments received for the draft, additional tests, verifications and other considerations are required
- SAR probes are calibrated at specific frequencies according to specific tissue dielectric parameters
 - each calibration point is valid for a narrow range of frequencies and tissue dielectric parameters (ϵ_r and σ)
 - therefore, separate verification for system measurement accuracy is required for individual probe calibration points
- when head and body tissue dielectric parameters are required to test a device, separate SAR system verifications are required
 - daily verification of each liquid is usually not necessary when liquid parameter tolerances are maintained in a controlled environment
 - typically every few days is sufficient or when liquid is changed



Multiple Transmitters

- multiple transmitter grant note concerns
 - do not blindly apply a “no collocation” grant note to devices that are designed to operate in simultaneous transmission conditions
 - the concern is “simultaneous transmission”, not “collocation”
 - simultaneous transmission is allowed by a number of the KDB procedures
 - many transmitters are designed to collocate; for example, USB dongles, WLAN or Bluetooth etc. and simultaneous transmission may be applicable to some product configurations only
 - getting an initial grant for mobile exposure conditions with a “no collocation” condition can introduce multiple layers of difficulties to enable portable exposure conditions through subsequent class II permissive changes
- when incorporating multiple transmitters into other products
 - for example, USB dongles and plug-in cards have been considered for use in certain non-transmitting products for special use
 - a KDB inquiry is recommended to address the RF exposure and approval concerns for individual implementations



Reporting SAR Numbers

- the highest reported SAR values have been identified on grants according to
 - exposure conditions: head, body-worn accessories and other use conditions
 - according to the frequency bands covered by the radio services
- to accommodate evolving products and technologies with multi-use configurations and to maintain consistency and simplicity
 - identify the highest measured SAR among all frequency bands and radio services according to the following categories
 - head – touch, tilt, left, right for SAM
 - body-worn accessories – among all accessories and distances tested
 - must identify body-worn accessory and distance restrictions separately
 - product specific use conditions – standalone 1-g SAR not related to head or body-worn accessory use
 - this typically applies to laptops, tablets, peripheral transmitters, other accessories and antennas, certain UMPC/smart phone operations etc.
 - identify any installation and distance restrictions separately
 - simultaneous transmission – according to SAR exclusion analyses and volume scan measurements
 - the highest of all standalone SAR used to determine SAR to peak location ratio SAR exclusion is compared to the other simultaneous transmission SAR to determine the highest SAR to report
 - extremity (hands, wrists, feet, ankles) – when it is measured; identify only the extremity assessed for SAR
- for example, the highest reported SAR for head, body-worn accessory, product specific (or related) use and simultaneous transmission conditions are W/kg respectively





KDB Inquiries

- typical causes for KDB inquiry delays
 - insufficient information
 - listing generic transmitter parameters or general product descriptions with no specifics
 - unclear requests with no questions identified
 - attaching partial results and reports with no further description or explanation
 - no follow-up responses to finalize test requirements
 - incomplete results based on incorrect test setup show up at the last minute for final PBA approval
 - results in reports are unsubstantiated
 - lack setup descriptions, test parameters or essential details
 - especially when power reduction, sensing mechanisms and/or simultaneous transmission are involved
 - test lab KDB inquiry info not provided to TCB to facilitate review and approval or missing when it is required to establish test requirements



PBA Status

- HSPA⁺ in uplink
 - there have been only a few KDB inquiries for HSPA⁺
 - this will remain on the PBA list until activities are increased
 - to identify issues etc
- occupational PTT radios
 - when tested with respect to procedures in KDB 643646, PBA is not required when the highest reported SAR is ≤ 6.0 W/kg
- WiMax
 - when tested with respect to procedures in KDB 615223, including the test reductions provisions described in earlier TCB workshop, PBA is not required when all of the follow are met
 - highest reported (scaled) SAR is ≤ 1.2 W/kg
 - maximum DL:UL symbol ratio is 29:18
 - AMC zone is not used
 - maximum burst average output power in all configurations are ≤ 24 dBm
 - WiMax SAR procedures may need further update in the near future
- when PBA is not required, applications can be audited to address issues



KDB 616217

- for the original KDB 616217 procedures
 - it has been indicated in earlier TCB workshops that the display screen only procedures are becoming obsolete and insufficient to support current generation laptop, netbook and notebook products
 - to address multiple transmitter configurations and simultaneous transmission requirements
 - the procedures have continued to raise permissive change problems
- KDB 616217 Supplement
 - the supplemental procedures have been available for about 18 months to address earlier problems
 - it has been explained multiple times that the original KDB 616217 procedures will be discontinued
- there are plans to update KDB 616217
 - to streamline the procedures according to current products to alleviate many of the on-going problems
 - comments and inputs on current and future generation products would be useful for planning the revision
 - to be submitted as comments through KDB inquiries